Toward automatic near-real-time detection of travelling ionospheric disturbances (TIDs) driven by lower atmosphere and near-surface geophysical events

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Lower atmosphere and geophysical near-surface events such as severe weather and natural hazard events generate acoustic and gravity waves and perturb the ionosphere, generating travelling ionospheric disturbances (TIDs). The TIDs manifest themselves as fluctuations of plasma density that propagate as waves. Near-real-time (NRT) detection, characterization and tracking of TIDs are of the greatest importance for Space Weather applications, but also for future monitoring and assessment of natural hazards from the ionosphere.

This contribution will present our recent developments in the field of automatic NRT detection of TIDs of different origins in data series of total electron content (TEC) by GNSS. Recently, two NRT-compatible methods have been developed by our research team. The first one can both capture disturbances with high TEC derivative (dTEC/dt) and determine their velocity and direction of propagation in NRT (Maletckii & Astafyeva, SciRep, 2021, doi: 10.1038/s41598-021-99906-5). This method, however, fails to detect TIDs with lower rate of TEC change. The second technique is based on Machine Learning to automatically detect disturbances in TEC data series and to determine the arrival time (Brissaud & Astafyeva, GJI, 2022, doi: 10.1093/gji/ggac167).

In this contribution, we will give an overview of the recently developed monitoring tools for co-seismic travelling ionospheric disturbances and other TIDs (driven by volcanic eruptions, tsunamis, tornadoes, large convective storms), and recent progress regarding both ionospheric dataset curation and new deep learning technologies.

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